TAMPERE POLYTECHNIC UNIVERSITY OF APPLIED SCIENCES

Environmental Engineering

Final Thesis

Sami Ahmed Khan

Flood Management in Bangladesh

Supervisor Marjukka Dyer, Principal Lecturer

April 2007

Tampere

Sami Ahmed Khan

Flood management in Bangladesh

Final thesis
37 pages, 1 appendix
Supervisor
Principal Lecturer, Marjukka Dyer
April 2007
Keywords
Flood, Flood Management, Sanitation, Dry Toilet, Solutions.

ABSTRACT

The aim of the thesis is to find out solutions to prevent floods to take over built areas. The information which is provided in this thesis is based on experiences gained during several years in flood management in Bangladesh, with strategies that have been observed after a number of disastrous floods. The introduction of an integrated approach for flood management in particular has been reflected in recent plans for flood and water management.

The frequency of abnormal floods in Bangladesh has increased substantially in the past few years, causing serious damage to lives and property. The most important questions that need to be focuses are: What causes the devastating floods? and Is there any solution to the problem?'

The main causes of flooding are generally considered to be results of heavy monsoon downpour and synchronization of flood-peaks of the major rivers. Some other important factors that also deserve serious consideration as possible contributors to the recent floods are river bed aggradations due to Siltation and damming of rivers, soil erosion due to unwise tilling practices and changes in the base level of the rivers due to local sea level rise. Also inadequate sediment accumulation on flood plains, excessive development and population growth, deforestation in the upstream region, and a possible increase in the watershed area due to seismic and neotectonic activities in the region will be discussed in this paper.

Sami Ahmed Khan

Tulvahallintaa Bangladeshissa

Tutkintotyö 35 sivua ja 1 liite
Työn valvoja Yliopettaja Marjukka Dyer
Huhtikuu 2007
Avainsanat tulvahallinta, kuivakäymälä,

TIIVISTELMÄ

Tämän tutkintotyön tarkoituksena oli selvittää sekä tällä hetkellä käytössä olevia sekä nyt kehiteltävinä olevia tulvansuojeluratkaisuja Bangladeshissä.. Työssä käydään läpi Bangladeshissa jo toteutettuja usein perinteisistä tulvasuojelutoimenpiteistä lähteviä ratkaisuja, joiden tarkoituksena on tulvasuojelutoimet usein toistuvissa, lähes vuosittaisissa tulvissa. Viime aikoina tulva- ja vesihuoltosuunnitelmiin on vaikuttanut myös integroidun lähestymistavan tulo tulvasuojeluun.

Epätavallisten tulvien esiintyminen Bangladeshissa on kasvanut huomattavasti viime vuosina ja aiheuttanut paljon vahinkoa niin ihmisille kuin omaisuudellekin. Tärkeintä olisi selvittää, mikä aiheuttaa tuhoavia tulvia ja onko niiden tuomille ongelmille ratkaisua.

Tulvien aiheuttajina pidetään rankkoja monsuunisateita ja suurten jokien tulvahuippujen samanaikaista esiintymistä. Mahdollisina osasyinä viimeaikaisiin tulviin on mainittu mm. jokiuomien nousu hienoaineksen kerääntymisen tai patoamisen johdosta, maan kuluminen huonojen kyntökäytäntöjen vuoksi, jokien vedenpintojen muutos paikallisen merenpinnannousun ja maansortumisen vuoksi, liian vähäinen lietteen kerrostuminen tulvatasanteilla, maan liiallinen kehitys ja jatkuva väestön kasvu, metsien väheneminen yläjuoksuilla ja vuoristossa sekä mahdollinen vesistöalueen kasvu alueellisten seismisten muutosten vuoksi.

Tässä työssä käydään läpi yllä mainittujen syiden merkitystä ja niitä toimenpiteitä, joihin voitaisiin ryhtyä, mikäli asiaa katseltaisiin kokonaisvaltaisemmin myös taloudellisista ja sosiaalisista lähtökohdista kuin vain rakenteellisia ratkaisuja tekemällä.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

DT	Dry Toilet
FARAKKA BARRIAGE	A river barrier between Bangladesh and India
FCDI	Flood Control, Drainage and Irrigation
FCD	Flood and Coastal Defense
FFWS	Flood Forecasting and Warning System
CNG	Compressed Natural Gas
NWP	National Water Plan
FAP	Flood Action Plan
EIA	Environmental Impact Assessment
NWPo	National Water Policy
NWMP	National Water Management Plan
CDMP	Comprehensive Disaster Management Plan
EA	Embankment Act
DA	Drainage Act
CA	Canal Act
NWC	National Water Code
NGO	Non-Governmental Organizations
UNICEF	United Nations Children's Funds
UNDP	United Nations Development Programme
WHO	World Health Organization

1. INTRODUCTION

This is a final thesis for the Degree programme in Environmental Engineering, Tampere Polytechnic University of Applied Science. The topic of the thesis is Flood Management in Bangladesh. The management plan was done in three months period between February 2007 and April 2007. The thesis is more theoretical than practical as all the information is based on internet and book references. It was not possible for me to visit Bangladesh and study flood.

1.1 General Information

Bangladesh is one of the most flood prone countries in the world which is situated in south Asian sub-continent. The country has about 130 million populations with an area of approximately 147,000 sq km. It is one of the highly dense populated countries and every year different flood types and magnitudes occurs because of its unique topography and geographical location. At least eight extreme flood events occurred affecting about 50-70% of land area during last fifty years. Due to the floods economic loss was huge, e.g. in two consecutive floods of 1987 and 1988 flood damage was estimated at US$ 2.2 billion and in 1998 flood damage was estimated at US$ 2.8 billion. Flood management in Bangladesh is, therefore, perceived as an indispensable component of poverty reduction initiatives./11/

Figure1. Location of Bangladesh

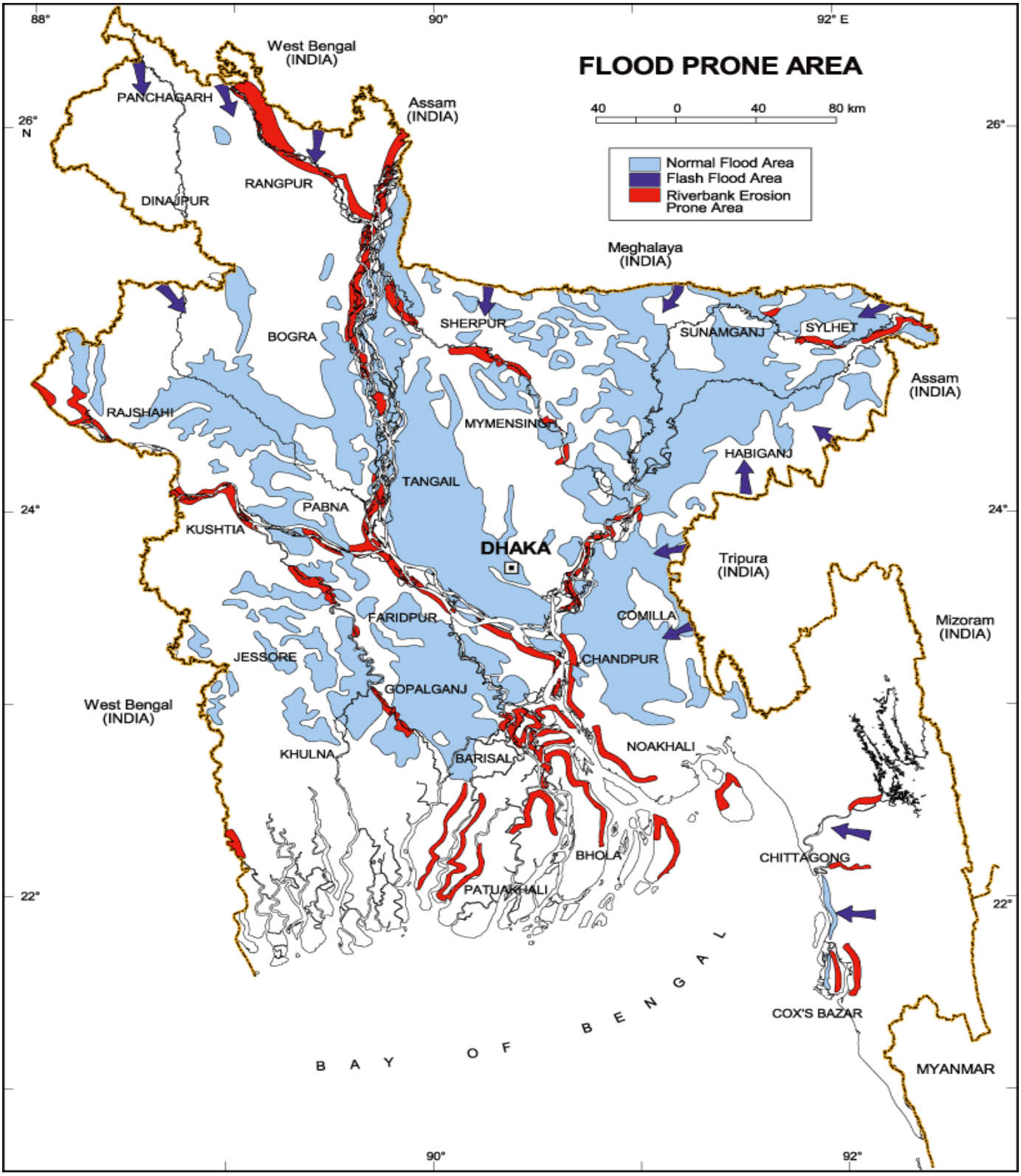

Figure 2. Flood Prone Area.

2. TYPES OF FLOOD

There are four types of flood which are commonly occurred in Bangladesh:

- Flash flood
- Rain-fed flood
- Rivers' flood
- Flood due to cyclone (Storm Surges)

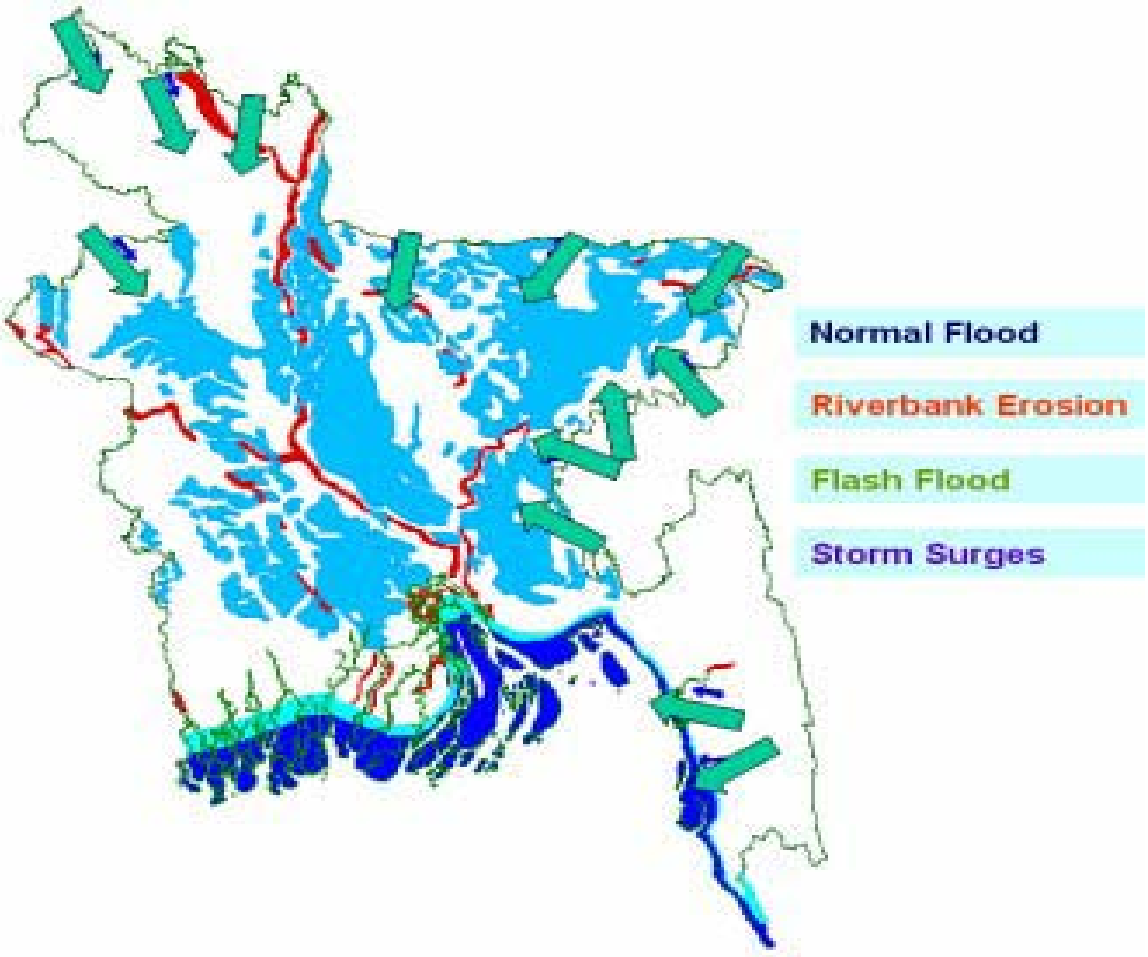

Figure 3. Four flood type's area.

2.1 Flash flood

It is a type of flood which can be described by observation of fall in water levels and by rapid water rise. It occurs during mid-April before the on-set of the south-westerly monsoon and when it occurs it can last between few minutes to few hours./2/

Flash flood occurs mostly in the northern most area, north-central part, northeastern part and southeastern part of Bangladesh. These Northern land areas are lying mostly at foothills but most of the hilly catchments in India and if it rains heavily in the Indian parts of the catchments the run-off quickly accumulates and flow to Bangladesh causing severe flood./2,10/

2.2 Rain-fed flood

This type of flood generally happens in the Gangetic deltas in the south-western part of Bangladesh where most of natural drainage systems are being deteriorated due to fall in up-land inflow from the main river Ganges and are increasing in low-lying urban areas./2/

Rain-fed floods occur due to improper drainage system mainly due to constructions of unplanned roads and illegal operation of river courses. During heavy rainfall the disturbed drainage cannot carry the run-off generated due to rain. As a result causing floods./10/

2.3 Rivers' flood

This type of flood is mostly common in Bangladesh and it occurs during monsoon season along the river and covered 50% to 70% of the country's land area. The country experienced many severe floods in the past 50 years and one of the most flood affected year was in 1998 in terms of magnitudes and during./10/

The figure 4 below shows the affected areas in that year:

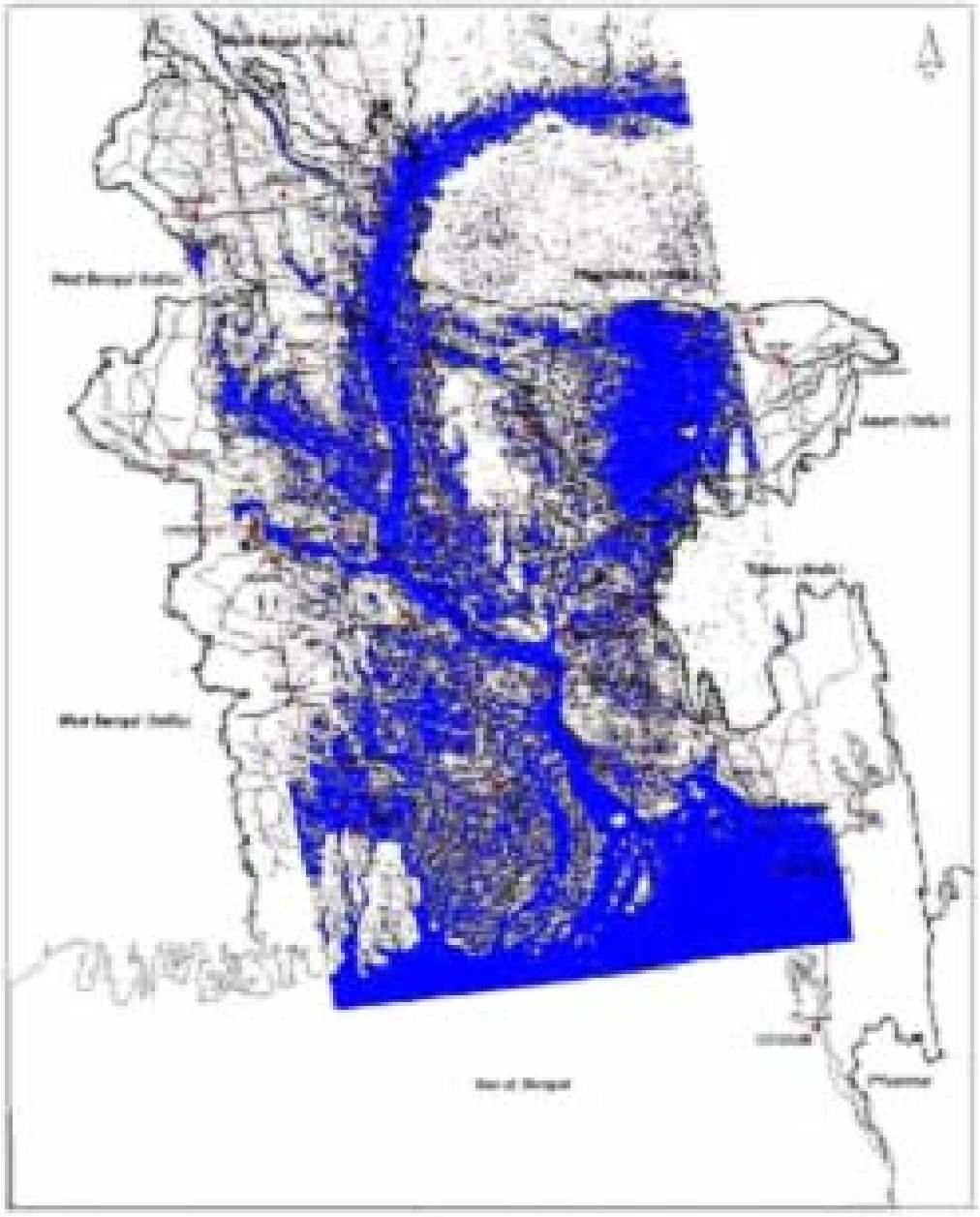

Figure 4. Flood in 1998.

2.4 Flood due to cyclone

In Bangladesh the coastal line of the northern part of the Bay of Bengal is about 800 km and this type of flood occurs alongside the coastal area. The entire coastal belt is flooded when cyclone hits strongly and the approximate height of the surges is about 10 m to 15 m, which sometimes cause great loss of lives. From June to September coastal areas are also subjected to tidal flooding./10/

3 HYDROLOGY

Bangladesh in most cases being the lower riparian country and it has a unique hydrological regime. It has 230 rivers, of which 57 are international. There are three large Tran boundary river systems; Ganges, Brahmaputra and Meghna (Figure 6, 7, 8), the world is covering about 1.7 million sq km of combined total catchments area extending over Bhutan, China, India and Nepal, flow through Bangladesh. And out of these huge catchments only 7% lies in Bangladesh. The major rivers have a length of 500 to 2500 km and width range from 1 km to 20 km, with very flat slopes./6, 11/

During the monsoon season the flood regime has been characterized by means of inundation of the different land types, which have been divided into five categories, ranging from very low to high land. All other types are subjected to flood inundation to different degrees except for high lands, which cover 29% of the country's total area, Human settlements can be found in all other land categories, excepting in very low lands./6/

Severe floods with devastating effects on people's livelihoods used to happen once every twenty years but they are now occurring every five to seven years, taking place in 1987, 1988, 1995, 1998 and 2004. During the last 50 years, at least 8 extreme flood events occurred affecting 50% of land area. These extreme events are generated by excessive rainfall in the catchments./11/

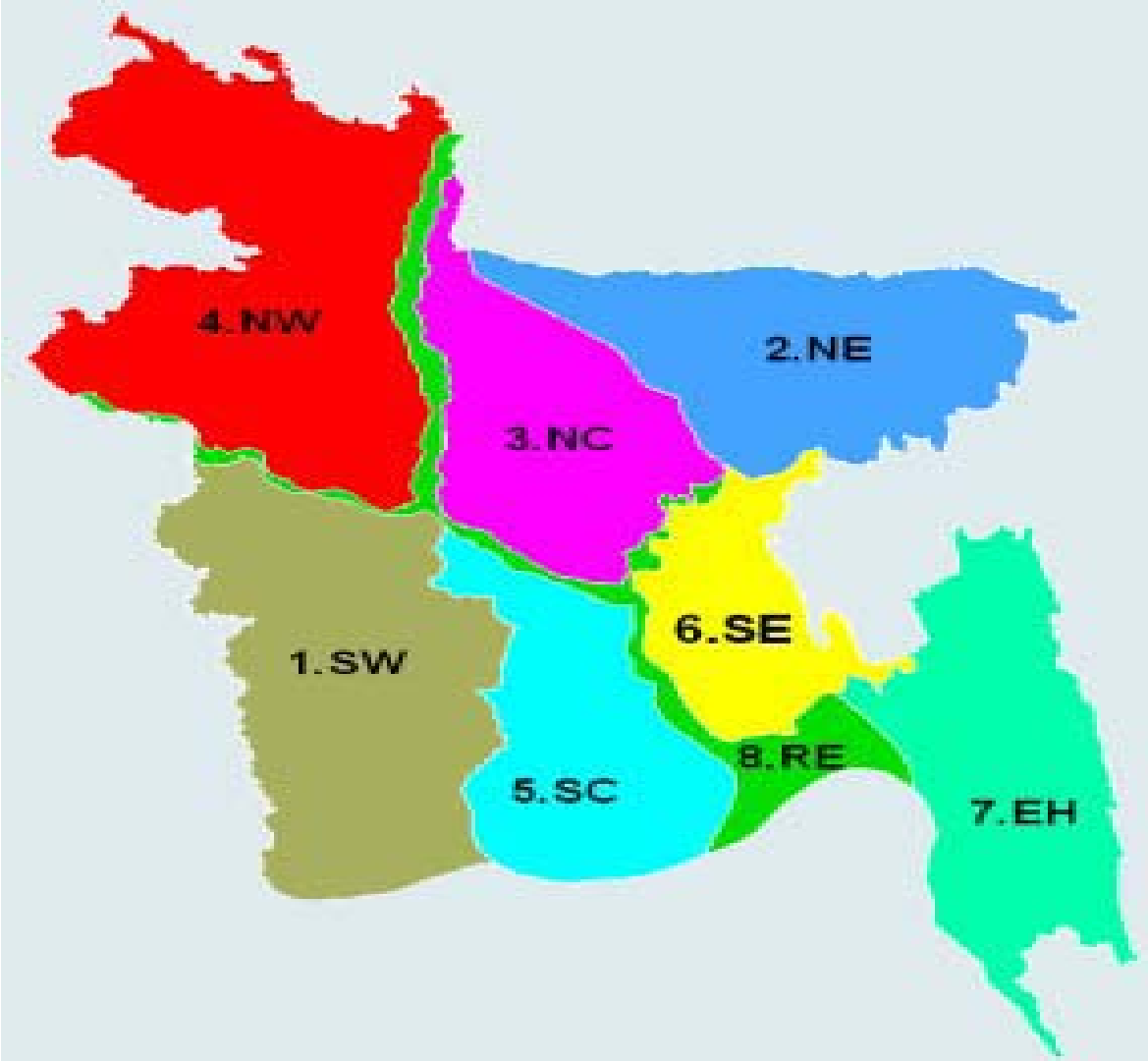

Figure 5. Hydrological regions of Bangladesh

An extreme flood situation usually occurs all over the country when the water levels in the three major river systems rises simultaneously and cross the danger marks which usually starting from mid-July and continuing until mid-September. The duration of these extreme events normally extends from 15 days to 45 days and this was observed during those which occurred in 1987, 1988, 1995, 1998 and 2004, in terms of magnitude and duration the latter having been the severest one./11/

4. CAUSES FOR FLOODING

There are several causes for flooding which are well demonstrated in the following picture:

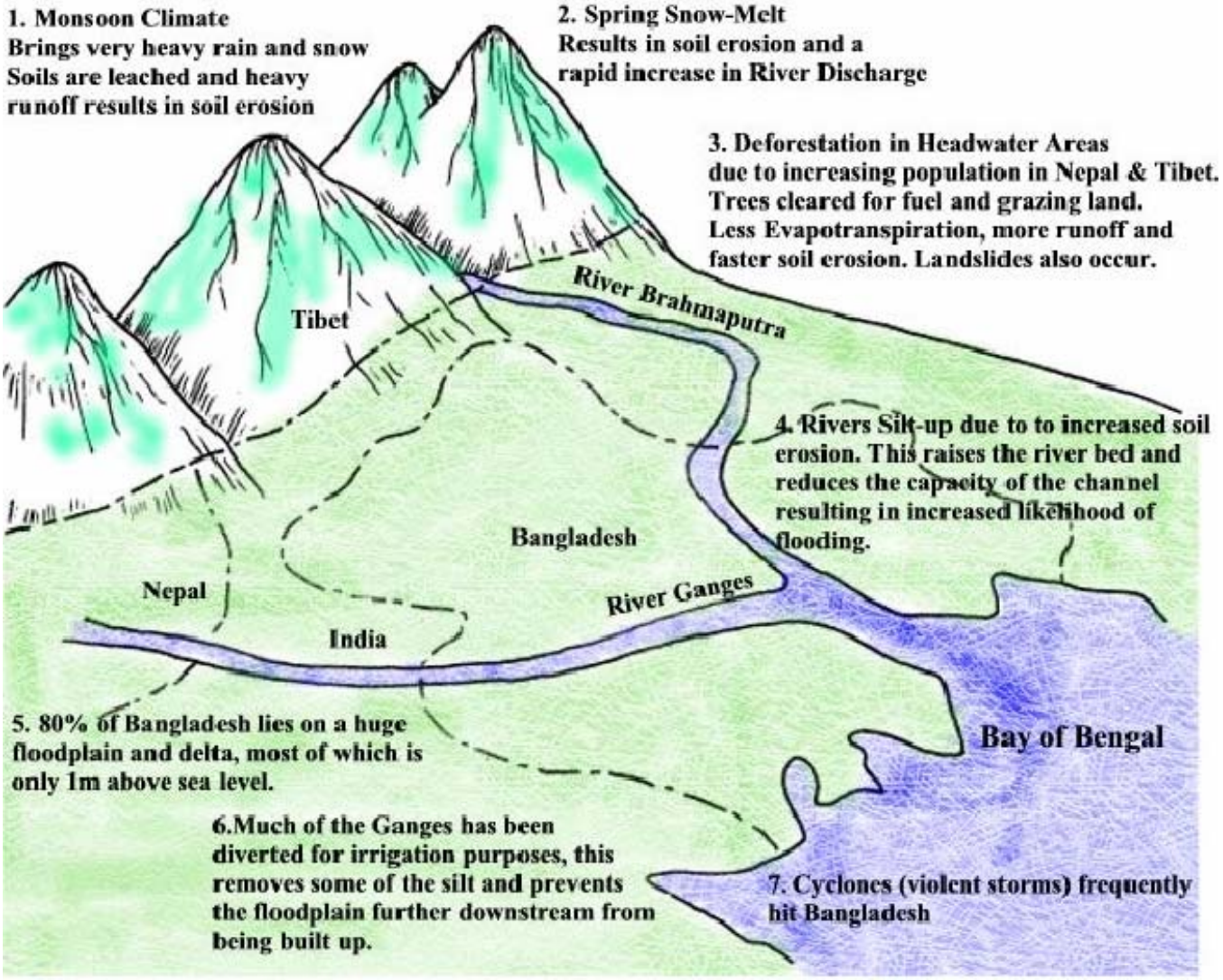

Figure 6. Some causes for flood.

The causes for flooding can be divided into two categories:

- Short-term causes, and
- Long-term causes

4.1 Short-term causes

4.1.1 Monsoon Season

Flood can cause from an increased amount of precipitation. The primary causes of flood in Bangladesh is thought to be from the above normal monsoon downpour in the Ganges-Brahmaputra-Meghna drainage system. However, it is not known whether the heavy precipitation is actually an effect of other processes like forests termination in the upstream region or the climate changes./14/

4.1.2 Synchronization of flood peaks

For the major three rivers (Figure 7, 8) the synchronization of flood peaks took place within a two week time period, causing a sudden increase in water level in virtually all areas of the country that reduce the water carrying capacity of the drainage system and decrease land elevation with respect to the base level of the rivers in Bangladesh./14/

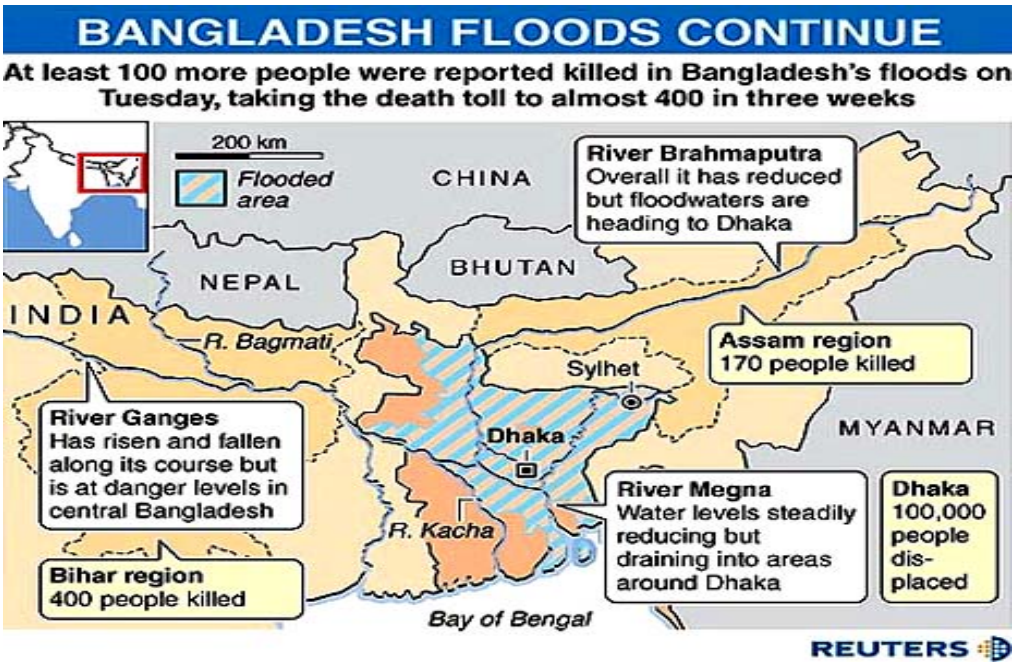

Figure 7. Showing how Bangladesh is getting flooded from surrounding rivers.

Figure 8. The three rivers making 'Y'- shape called Delta Rivers.

4.2 Long-term causes

4.2.1 Sea level rise

The Ocean is the final destination of all the rivers. With respect to sea level in an area the land elevation is measured. Therefore, any change in sea level causes land elevation to change. Sea level is rising globally at the present time and if it rises in an area at a rate faster than the rate of land aggradations due to sedimentation, then land elevation decreases. Any decrease in land elevation can cause increased inundation by rivers overflowing at bank full stage. The rate of local relative sea level rise is 7mm/year around the coastal areas of Bangladesh. An increase in sea level raises the base level of rivers, which in turn reduces the gradient of river flow. As a result, the discharge of rivers decreases as the water flow becomes sluggish, creating a backwater effect further inland. The backwater effect caused by sea level rise can result in more flooding of land from accumulation of river water inland which certainly seems to be one of the reasons for the increase in flood intensity in Bangladesh in recent years./5, 14/

4.2.2 Compaction and subsidence of sediments

On a delta plain, sediments are rich in decomposed organic matter, and are subject to compaction due to dewatering and the weight of the overburden. Most deltas subside due to the weight of the thick sediment layer. Subsidence along with compaction reduces land elevation with respect to the rising sea level. Even though the rate of subsidence and compaction are not yet well documented, based upon our knowledge about processes active in other deltas it can be assumed that Bangladesh's delta is also undergoing subsidence and compaction./5, 14/

4.2.3 River bed aggradations

The large-grained sediments are deposited near the source area on the river beds due to relatively higher settling velocity, forming sand bars. If sedimentation continues on the riverbeds the river gradient decreases rapidly because of low gradients and high sediment loads, the riverbeds of most of the rivers in Bangladesh aggrades very quickly. River bed aggradations are most pronounced for the Ganges and its distributaries. The riverbed has aggraded as much as 5-7 meters in recent years from the border with India to the point where the Ganges meets the Brahmaputra. River bed aggradations reduce the water carrying capacity of rivers, causing them to overflow their banks and it is so pronounced in Bangladesh that changes in river bed level can be observed during one's lifetime./11, 14/

4.2.4 Accumulation of inadequate sediment

The earlier described data showed that the average sediment accumulation rate for the last few hundred years in the coastal areas of Bangladesh is 5-6 mm/year, which is not enough to keep pace with the rising sea level. As the result, net land elevations must have been decreasing over time, resulting in more flood inundations. The only way for land to counter the effects of a rising sea is for sediment to accumulate at a rate that is sufficient to keep pace with the rate of sea level rise. The materials which are carried in solution by the stream or river is called dissolved load. The most common constituent of the dissolved load are bicarbonate (HCO_3^-), and sulfate (SO_4^{2-}) ions and ions of calcium (Ca^{2+}), Sodium (Na^+) and magnesium (Mg^{2+}). An ion is an atom or group of atoms with a positive or negative charge resulting from a gain or loss of electrons. Typically the above 5 atoms and molecules comprises more than 90% of the river’s dissolved load and it is the suspended load which when deposited in undesirable locations produce sediment pollution. /2, 3/

4.2.5 Deforestation in the upstream region

An extreme amount of deforestation increased in the hills of Nepal due to rapid increase in population in the Indian Subcontinent over the course of the present century to meet the increasing demand for food and fuel wood. Deforestation of steep slopes is assumed to lead to accelerated soil erosion and landslides during monsoon precipitations. This in turn is the result of devastating floods in the downstream regions in Bangladesh./14/

4.2.6 Rivers damming

River damming reduces the velocity of water flow downstream from the dam. As a result of reduced velocity, the sediments carried by the river start to settle down faster on the riverbed, causing riverbed aggradations and in turn reducing the water carrying capacity of the river. The Baraka Barrage (river barrier between Bangladesh and India) on the Ganges has already caused tremendous damage to the agriculture, navigation, environment, and hydrodynamic equilibrium in Bangladesh./14/

4.2.7 Soil erosion due to tilling

The land surface becomes more susceptible to soil erosion because of Ploughing. The surface run-off can easily wash away the topsoil from cultivated land. This surface erosion reduces land elevation, which in turn increases flood intensity in an area. The land elevations in Bangladesh must have been reduced over time due cultivation. Aside from this, the rapid river bed aggradations in Bangladesh eventually increased due to the tilling on the mountain slopes of the Himalayas which is thought to be responsible for massive soil erosion in Nepal./14/

4.2.8 Excessive development

In overcrowded Bangladesh the enormous amount of increasing population produced an extra pressure on the land and as a result, agricultural lands are given way for roads and to real state for housing developments. This continuous growth in populations and urbanizations creates flooding problems in Bangladesh./14/

There is a greater lag time between intense rainfall and peak stream flow prior to urbanization. The lag time is shortened after that, peak flow is greatly increased, and total run-off is compressed into a shorter time interval creating favorable conditions for intense flooding. For example, floods are almost 6 times more indefinite in a city that is totally served by storm drains and where 60% of the land surface is covered by roads and buildings than before urbanization./4, 14/

4.2.9 Seismic (Earthquake) and Neotectonic activities

A vibration in the earth or the movement of land produced by earthquake is known as seismic. This can change the structure of the region and castrate river courses. Bangladesh lies on the Indian lithosphere plate, which is pushing against the Asian plate, causing growth of the Himalayas and occasional earthquakes in the region. A sudden change in a river course can cause substantial flooding. The northern regions of Bangladesh are earthquake-prone. Neotectonic activities (recent movements in the Earth's crust) are affecting river courses in the area. Most of the recent floods have been approximately simultaneous with earthquake activities. The floods of 1988 and 1991 also are coincident with earthquake activities in northern parts of Bangladesh. A powerful earthquake occurred recently on 20th October 1991 in northern India, which was preceded by a flood in Bangladesh and was followed by another flood in the Ganges valley in India. Floods can be either a cause of or an effect of an earthquake. Flood water places an extra hydrostatic pressure on unstable and mobile crustal blocks. If this extra pressure reaches the threshold strain limit along a fault zone or plate boundary within the Earth's

crust, it can cause an earthquake to occur due to a sudden release of the strain energy accumulated over time. Similarly, an earthquake can change the surface drainage pattern and consequently the course of a river, causing sudden flooding in an area. Historic records show the relationship between floods and earthquake even though the cause and effect relationship between them is not very clear. /2, 6, 14/

4.2.10 Climate Change

Scientists assumed that the flood increased as the world gets warmer, which is absolutely true as the world is about to enter a period of rapid warming. Rising sea level of even greater magnitude will cause flood on the low land and slow the speed at which rivers can remove water from the land. Bangladesh will be severely impacted by such an increase in sea level. Besides many other adverse environmental, economic, and climatic consequences, the base level of all rivers will change following any change in the sea level. The greenhouse effect will cause frequent cyclone as a result of high temperature will lead to flood problem and the rainfall could increase by 10% to 15% by the year 2030. /8, 16/

Millions of peoples will be forced to migrate to neighborhood countries like India and Burma if the sea level rises 45cm. That would reduce Bangladesh's land area by 11% and force about 5.5 million people to move, and in case of a 100 cm rise 20% of the land area will be lost, causing 15 million people to find new homes. Millions more will be forced to live in flood endangered areas. /8, 16/

5. EFFECTS OF FLOOD

Disaster flooding in Bangladesh effects in many ways. Flooding causes death and injuries to people and every year more than 300 to 500 people will die and millions of other people will become homeless and suffer starvation. Flooding brings too much water which leads to the damages of roads, collapse of bridges or traffic congestion, which affects the daily life of all concerned. It will also destroy farmland in rural areas. Flooding causes economic loss of about approximately USD 30 billion every year and after big floods government has to input many resources for aiding and reconstruction, which also bring extra economic stress to the public./12/

Flooding brings many diseases such as malaria, dengue, yellow fever, encephalitis and filariasis from mosquito bite, since the mosquitoes grow very fast in dam water and spread diseases in the very same rate. Other diseases like dysentery, common cold, cholera, break bone fever, food poisoning etc. can also result from domestic waste or improper sanitation, as all the waste is carried by the flood and will float all over the streets and public places. /5, 7/

6. FLOOD MANAGEMENT AND SOLUTION PLANNED

Flood management can be divided into five parts:

- Structural measurement
- Non-structural measurement
- Geologic or alternative solutions
- Reduce of carbon emission
- Usage of proper sanitation or dry toilet

6.1 Structural measurements

Over the second part of last century flood management strategies adopted in the country have continuously evolved in three distinct phases of their development, and with mixed experiences. At the beginning, the emphasis was on structural measures through the implementation of some large-scale Flood control, drainage and irrigation (FCDI) projects. After some time later it has been realized that a huge amount of investment is required to implement the idea as well as it is going to take more time to complete. It was then opted for the construction of small and medium scale Flood and Coastal Defense (FCD) projects so as to provide early benefits. After this, it was observed that other sectors related to water resources development and utilization should also be taking care of like the way they do for agriculture. Environmental protection has been given first priority. As a result, since the 1960's about 628 large, medium and small-scale FCDI projects have been implemented; they comprise levees and embankments, drainage channel improvements, drainage structures, dams and barrages, pumping systems, etc. They have provided flood protection to about 35% of the total area, the meaning is about 5.37 million ha of land. /10, 14/

Moreover, the back flow of flood water (the water enters from the three major river will be transfer to Bay of Bengal) through drainage can be implemented and in that case more drainage channels and pumping systems have to be established as mentioned earlier above the investment involvement is high. But studies showed that the fly-over bridges that are constructed in the capital city to reduce traffic jams cost about USD 67million.

The government has invested for the flood management around USD 4 billion to the water sector used mainly for the FCDI project during the last 40 years, meaning an annual expenditure of 200 million USD./11, 12/

To maintain drainage channels and structures and also to raise new improved drainage channel with bigger structures will reduce the maximum amount of flood affecting the

capital city. It is also hoped that the other developing cities would benefit this money and will utilize it for improved flood management.

6.2 Non-structural measurements

It has been proven that structural measures alone are not the only solution to improved flood conditions. Non-structural measures like Flood Forecasting and Warning System (FFWS) have been introduced to share the flood problems. In early 70's the FFWS has been established in Bangladesh and was modernized in 1996 and then again in the year 2000. It now covers all the flood-prone areas of the country with 85 flood-monitoring stations, and provides real-time flood information and early warning with lead-times of 24 hours and 48 hours. The FFWS is currently assisting Government, disaster managers and the communities living in the flood prone areas in matters of flood preparedness, preparation of emergency mitigation plans, rehabilitation and agricultural planning./1, 10/

Furthermore, for the flood mitigation more emphasis is now put on other non-structural means in particular by adopting a policy of involving communities in flood management, the stopping of encroachments on the flood plains through legislation controlling the developments in the flood plains and wetlands. However, a new concept is being introduced of controlling the flood as per desire of the stakeholders, instead of protecting some areas to make them completely flood-free. /1, 10/

6.3 Geologic solution

We need to understand the geologic processes before we express any kind of solutions that causes flood. In the entire region flooding in Bangladesh is a part of the overall hydrodynamic process. 'The geologic solution is more farsighted in nature; it is to permit the delta to grow both vertically and horizontally at a rate that would keep pace with the relative sea level rise in the region (Khalequzzaman 1991)'./14/

Further studies of geologic processes, namely hydrodynamics of the rivers and channels, dynamics of sedimentation, amount and rate of sediment accumulation, rate of erosion and subsidence, and rate of local sea level rise, is necessary in order for the success of any development plans or preventive measures to mitigate the flooding problem. While safeguarding the environment a better understanding of all geologic processes can help us to solve the problem of flooding./9, 14/

The geologic solutions of flood problem can be measured into two most important parameters: land elevation and water carrying capacity of the basin. Increases in land elevation and water carrying capacity of the rivers will reduce flooding propensity in Bangladesh. /9, 14/

The information below discusses the possible ways of helping to increase land elevation and capacity of the river basin:

6.3.1 Dredging of rivers

To increase the capacity of the river and elevation of the land continuous dredging of the rivers and channels and dispersion of the dredged sediments on the delta plain is necessary. These factors will in turn reduce the severity of annual flooding. For accelerated growth of the Ganges-Brahmaputra delta adequate sediment supply, accumulation and dispersion are primary requirements to maintain the pace with the rising sea level. /6, 14/

From a volumetric calculation of sediment shows that 100,000 m3 of sediment can be generate from a dredging process if a river increase 1 m in depth of a 1 km stretch with a width of 100 m of a river. Now, if this amount of sediment is dispersed constantly on the flood plains over a 1 km2 area on both sides of the river it will increase the elevation of the flood plains by 5 cm; and will also increase the discharge capacity of the river by 100, 000 m3. An increase in flood plain elevation of 5 cm may not seem very significant; but

in an area where the elevation gradient is only 10 cm/km, like the coastal areas of Bangladesh an increase in relative sea level of 5 cm is capable of shifting the shorelines in a landward direction by 0.5 km. The pre rate of local relative sea level rise exceeds the rate of sediment accumulation by 0.2 cm/year. At this rate, it will take 25 years for the sea level to rise 5 cm. Thus, occasional dredging of all rivers and channels in the low-lying areas affected by floods, and dispersion of the dredged sediment on the flood plains will not only increase discharge capacity of the rivers but will also help flood plain accretion to keep pace with the rising sea. /14/

6.3.2 Preventing land degradation

All the farmers in Bangladesh especially in the rural area should be advised to leave a few inches of stem remaining from their rice crops during harvesting before the rainy season because suspended sediments adhere to the stems of plants. They should also be taught and given more information about the problem of soil erosion including correct tilling practices such as putting tall earthen boundaries between large farm lands. Tilling at the edge of the boundary can prevent sediments from precipitation water drained by streams out to the channels. /7, 14/

6.3.3 Flood preparedness

Every individual should prepare themselves and take some measures about the upcoming flood, which also includes shelters and food. /5/

6.3.4 Inter-basin cooperation

Any major inter-basin development activity is almost impossible without regional cooperation between the co-riparian nations. Only certain percentages of the river basin area fall within Bangladesh. To make a successful inter-basin flood control projects it has to be designed to serve the common interests of the people of the countries

concerned. For example, construction of reservoirs in the upstream regions of the Brahmaputra to hold excess water during rainy seasons can reduce flood propensity in Bangladesh. During the summer months the trapped water can be used to produce electricity to meet some of the irrigation demands for Bangladesh./14/

7. REDUCE OF CARBON EMISSION

The world gets warmer due to global warming and as a result the chances for flooding increase rapidly. Cutting down the carbon emissions can also reduce flooding. One of the major sources of carbon emissions in the atmosphere is the transportation in Bangladesh. Compressed Natural Gas (CNG) could be used instead of petrol to all the vehicles. And the cost will be much less since CNG is produced in Bangladesh naturally. The community involvement and the government initiative should be strongly considered to implement this project.

8. USAGE OF PROPER SANITATION AND DRY TOILET

Health is increasingly being regarded as a holistic and socio-cultural phenomenon rather than a purely medical matter. These means that the four role of health management – prevention, promotion, cure and rehabilitation have to be integrated both into so called ‘complementary’ medical procedures and into socio-economic development patterns that place the physical and mental well-being of people as the first priority./4, 8/

Since the early 19th century death rates in South Eastern Asian countries have been increasing. The greatest death numbers are found within infants and children. Diseases which were rampant such as tuberculosis, cholera, dysentery, typhoid, typhus, smallpox, scarlet fever, measles, whooping cough and diphtheria are still dominate in Bangladesh. Many of the gastro-intestinal disorders are transmitted through faeces, so the most effective first intervention is to improve water supplies and sanitation. /8, 18/

Open dumps are the oldest and still the most common way of disposal of solid waste in Bangladesh. In many cases, open dumps are located wherever land is available, without regard to safety health hazards and aesthetic degradation. The waste is often piled as high as equipment allows. In some instances, the refuse is ignited and allowed to be burnt, in other words, it is periodically leveled and compacted. In addition to being unsightly, open dumps generally create health hazards by breeding pests, polluting the air, and often contaminated ground and surface waters. /2/

Drinking water contamination by excreta, food crops fertilized with human waste and fish from polluted waters, are all health hazards which can be significantly reduced. Over 100 million people in Bangladesh lack access to safe drinking water and adequate sewerage system. The World Bank estimates that the cost for providing adequate water and sanitation services range from USD 15 per person per year for simple rural system to USD 200 for urban systems with individual household taps and flush toilets. The benefits to be gained include increased productivity as well as improved health, so cost-effectiveness is extremely high. /8/

Since 21st century a new way of sanitation has been introduced worldwide and it is called 'Dry Toilet'. DT is the toilet that does not need water to operate and they are not connected to the sewage system. DT saves clean water and instead of releasing nutrients to the water resources the nutrients are recycled back after being composted to the soil.

The 'Dry Toilet-Technology' has been introduced for instance at the 'Dry Toilet Conference2003' in Tampere, Finland. To understand better the DT-Technology one has to define briefly the following terms:

- Dry toilets
- Nutrients re-cycling
- Water saving
- Water protection

- Hygiene: Better health can be achieved by controlling toilet waste management and education through personal and environmental hygiene.
- Equality: The attention has to be paid to Women's and Children's in designing sanitation, where no minority group of people will be given the chance of handling of domestic waste.
- Good management from the DT to the positive motivational influence of nutrients in the fields./17/

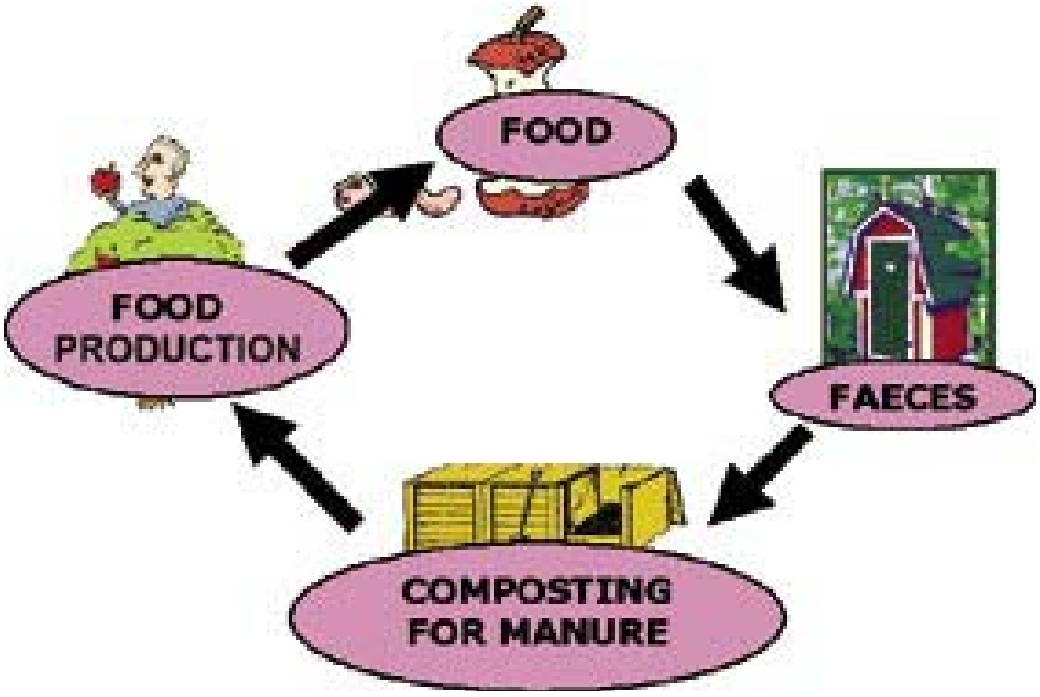

Figure 9. The Nutrients Cycle.

During the past years DT has developed by huge steps. Modern dry toilets differ a lot from the old toilets where all the excrements sunk straight to the soil and the smell was terrible. Still now the most common way in the rural areas in Bangladesh is to dig a hole into the ground where all the excrements sinks./18/

There are different types of DT, for example, they can compost or partly composting, electrical and urine separating. DT can be bought or self-made installed both in indoors and out doors./17/

a. **b.**

Figure 10. Dry Toilets.

The most effective way to introduced or promote DT-Technology in Bangladesh is to installed DT in public places and give them some knowledge and information's about it.

9. WATER MANAGEMENT INSTRUMENTS

Many rules and acts have been introduced since the 19th centuries for the flood management, for example, Embankment Act (EA), Drainage Act (DA) and Canal Act (CA), etc. and also legal instruments were used from the ancient time for the management of flood in Bangladesh. The government has found some inconsistencies in these laws and has come up with some new acts to manage flood compared to the practices of early sixties and has decided to publish a unified law and work which is now going on in the form of a National Water Code (NWC)./10/

Bangladesh has improved in good hydrological data collection system all over the cities, as well as an integrated hydrological database with about 40 years of data. There is also a real-time water level and rainfall data collection system from a selected number of stations for FFWS during monsoon months. All these data are used for planning and design of different types of hydraulic structures, construction of different infrastructures. /10/

10. POLICY

'In 1980, National Water Plan (NWP) was made for various aspects of water use and demand and the interests of different stakeholders involved in the water sector. From mid nineties a Flood Action Plan (FAP) was implemented, on the basis of which a National Flood and Water Management Strategy which was formulated in 1996 including policy guidelines for public participation in multi-criteria analysis and Environmental Impact Assessment (EIA) during implementing process in all future water sector projects.'/10, 14/

"In 1999 the National Water Policy (NWPo) was introduced, which guides all the activities in the water sector. Subsequently, a National Water Management Plan (NWMP) was prepared in 2001, cross-cutting different sectors of national economy in the light of Integrated Water Resources Management, to address conflicting water needs and to ensure equitable water use and balanced economic growth, into the next 25 years. The Plan includes also the management of water-induced disasters, e.g. floods, erosion and droughts. A Comprehensive Disaster Management Plan (CDMP) and Disaster Management Guidelines were also prepared, in which the responsibilities of different Agencies involved in disaster mitigation activities are delineated during pre-disaster preparedness, rescue and evacuation operation during disaster and post-disaster relief and rehabilitation" /10, 14/

11. DISCUSSION AND CONCLUSION

The aim of this case study was to find out the possible solutions to protect flood from creating any further damage in future. In the study, I approached some solutions which I believed if and when implemented, would be helpful to the people in Bangladesh. However, there were some similar solutions which have been thought of and even published in some books that deal with flood. Unfortunately they have never been implemented as they were written only for the general knowledge and they landed obviously only on the book-self as a “piece of antique collections”.

During flood season, people had to face many problems, the most severe of them being diseases. I mentioned in the thesis about the sanitation or dry toilet that might solve or minimize the problem with infectious diseases. But there is one thing that might not be in favor of DT, which is based in religion; about 90% of the populations in Bangladesh are Muslims. In Muslim culture usage of water is mandatory to keep oneself sacred after taking bath. And the DT-technology is the opposite what Muslim people do after bath.

However at present one can find in the market also different DT models which are designed keeping in mind the special needs of the people to whom the use of water is mandatory, e.g. for the Muslim people. They have an option for the user of a minimum amount of water. Therefore the discussion between either to use water or not to use water , which is costly, or to save water by using DT-technology, is possible. The out put of DT or the people’s reaction towards its use is yet to be observed after the technology will be introduced to the people of Bangladesh.

Overall, if the DT-Technology is used and other flood solutions implemented then the chances of flood and diseases can be minimize or faded away from Bangladesh.

REFERENCES

Literature (Printed)

1. H. BRAMMER. Floods in Bangladesh: II. Flood Mitigation and Environmental Aspects. *The Geographical Journal*, Vol. 156, No. 2 (Jul., 1990) DOI:10.2307/635323

2. EDWARD A. KELLER. *Environmental Geology*, Eighth Edition, Chapters 5, 7&12, pages 98, 112, 161, and 317. ISBN: 0-13-022466-9

3. AVIJIT GUPTA AND MUKUL G. ASHER. *Environment and the developing world*: Principles, Policies and Management. Chapter 7, page 111. ISBN: 0-471-96604-5

4. PATRICK C. KANGAS. *Ecological Engineering*: Principles and Practice. Chapter 2, page 25. ISBN: 1-56670-599-1

5. JAMES L. WESCOAT, JR. AND GILBERT F. WHITE. *Water for Life*: Water management and Environmental Policy. Chapters 7, 8, pages 109, 129, 139. ISBN: 0-521-36211-3.

6. ANDY D. WARD. STANLEY W. TRIMBLE. *Environmental Hydrology*, Second Edition. Chapters 1, 3, 5&12, pages 4, 55, 119 & 339. ISBN: 1-56670-616-5.

7. CHRIS PARK. *The environment*: Principles and Applications, Second Edition. Part IV, page 349. ISBN: 0-415-21770-9.

8. TIMOTHY O'RIORDAN. *Environmental Science for Environmental Management,* Second Edition. Chapter 16, page 417. ISBN: 0-582-3563-4.

Other References (Electronic):

9. FLOOD PROBLEMS IN BANGLADESH. *Earth and Environmental Science* [Online]. [Cited: 23rd February 2007]. Available from World Wide Web: http://www.springerlink.com/content/q46n04165005528x/.

10. WMO/GWP Associated Programme on Flood Management. [Online]. [Citied: 27th February 2007]. Available from World Wide Web: http://www.apfm.info/pdf/case_studies/bangladesh.pdf

11. BANGLADESH INFORMATION. *Bangladesh, an Introduction* [Online]. [Citied: 2nd March]. Available from World Wide Web: http://www.southasianfloods.org/regional/bangladesh/banginfo1.html

12. BANGLADESH INFORMATION. *Culture & Life styles* [Online]. [Citied: 2nd March 2007]. Available from World Wide Web: http://www.bangladeshinfo.com

13. VULNERABILITY OF BANGLADESH COASTAL REGION TO CLIMATE CHANGE WITH ADAPTATION OPTIONS. *An war Ali* [Online]. [Cited: 4th March 2007]. Available from World Wide Web: http://www.survas.mdx.ac.uk/pdfs/3anwaral.pdf

14. RECENT FLOODS IN BANGLADESH: POSSIBLE CAUSES AND SOLUTIONS. *Md. Khalequzzaman* [Online]. [Cited: 7th March 2007]. Available from World Wide Web: http://www.cs.albany.edu/~amit/BanglaFloods.txt

15. DEVELOPMENT AND CLIMATE CHANGE IN BANGLADESH: FOCUS ON COASTAL FLOODING ANDTHE SUNDARBANS. *Shardul Agrawala, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten van Aalst* [Online]. [Citied: 12th March 2007]. Available from World Wide Web: http://www.oecd.org/dataoecd/46/55/21055658.pdf

16. SEA CHANGE: *Flooding in Bangladesh* [Online]. [Cited: 25th March 2007]. Available from World Wide Web: http://www.wdm.org.uk/resources/briefings/climate/bangladeshflooding13112006.pdf

17. GLOBAL DRY TOILET CLUB OF FINLAND. *DT-Technology* [Online]. [Cited: 25th April 2007]. Available from the World Wide Web: http://www.drytoilet.org/dttechnology.html

18. GLOBAL DRY TOILET CLUB OF FINLAND. *A guide to sanitation and hygiene.* Tampere Polytechnic, university of Applied Science. [Online]. [Cited: 25th April 2007]. ISBN: 952-5264-49-1. Available in the World Wide Web:http://kirjasto.tamk.fi/julkaisu.htlm

APPEXDIXES

1. Some Lessons Learned

Bangladesh has experienced a lot from flood problems and still suffering with on-going floods. I have made some simple points about management of flood. They are:

1. *No one should approach alone for the management of flood; they should take or ask for help from NGO's, e.g. UNICEF, UNDP, WHO, etc.*
2. *There should be a combination of both structural and non-structural measures in flood management.*
3. *For poverty reduction developed countries should contribute to developing countries.*
4. *The activities of flood management should be sustainable.*
5. *The community's involvement should be very active and they all should participate in flood management and help people who are in danger or in need.*
6. *Citizens should always listen to weather forecasting news, either through radio or television.*